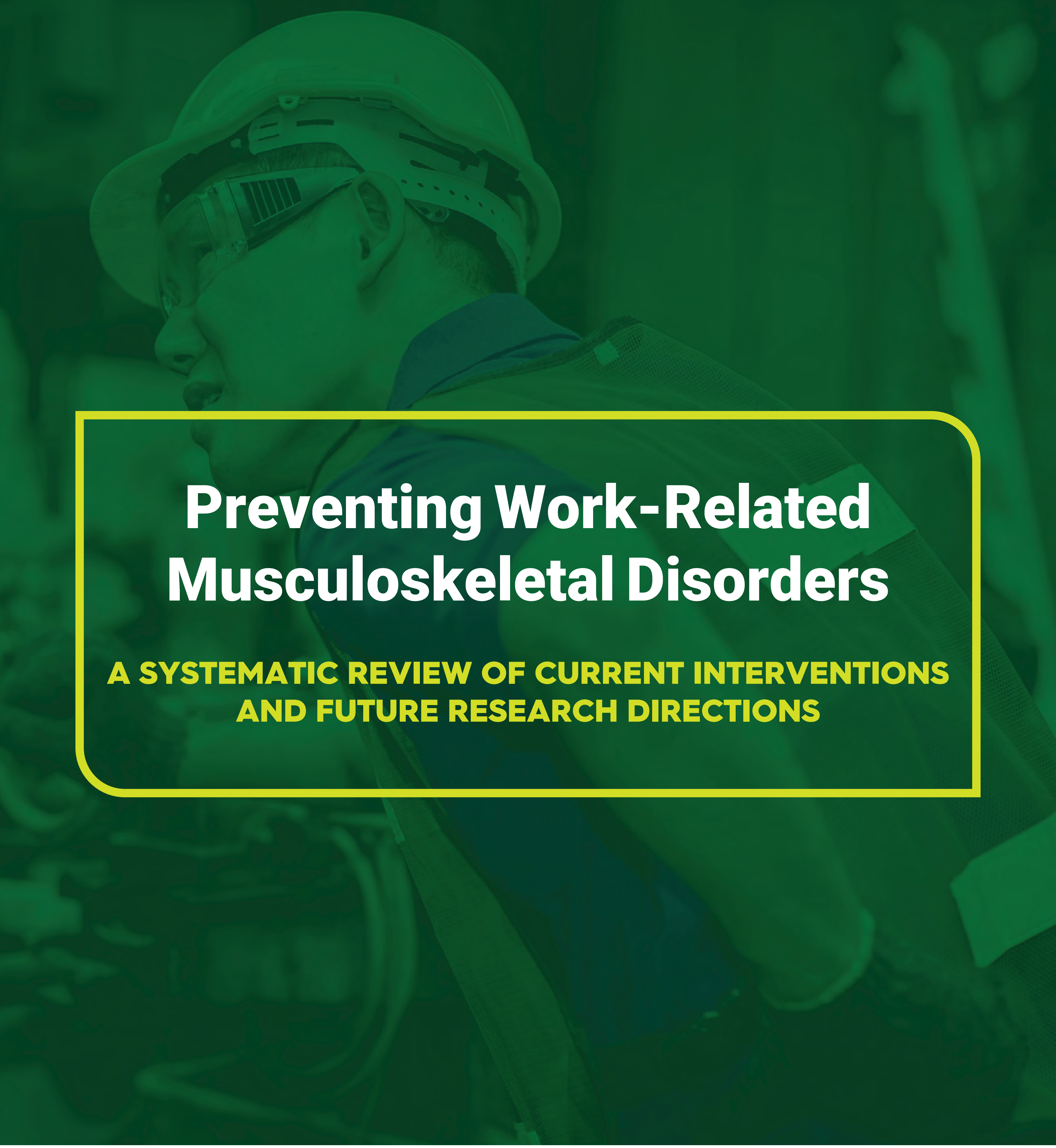

Preventing Work-Related Musculoskeletal Disorders

A SYSTEMATIC REVIEW OF CURRENT INTERVENTIONS AND FUTURE RESEARCH DIRECTIONS

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The National Safety Council is America's leading nonprofit safety advocate - and has been for more than 100 years. As a mission-based organization, we work to eliminate the leading causes of preventable death and injury, focusing our efforts on the workplace, roadway and impairment. We create a culture of safety to not only keep people safer at work, but also beyond the workplace so they can live their fullest lives.

Executive Summary

Musculoskeletal disorders (MSDs) are the most common global cause of disability and limitations to gainful employment (World Health Organization, 2021). According to the Liberty Mutual Workplace Safety Index, MSDs cost businesses in the U.S. private sector approximately $16.64 billion in 2019. Recognizing the need to address this prevalent workplace concern, research into the current state of workplace MSD interventions was undertaken to uncover promising solutions and determine future research needs.

A review was conducted of six electronic databases for peer-reviewed articles published within the last decade focusing on the effectiveness of workplace MSD interventions in preventing MSDs and MSD symptoms in the top 10 most afflicted industries. After applying the inclusion criteria, a total of 58 articles were eligible for this systematic literature review. Three domains were used to generate the seven categories of interventions within this report (refer to detailed definitions in the full report):

- **Physical Modifications** – comprised of two sub-categories that are concerned with 1) the physical environment and equipment as it relates to human interaction within the workplace; and 2) physical activity as it relates to human performance
- **Cognitive Processes** – concerned with mental processes and decision making among humans in the workplace
- **Organizational Change Management** – concerned with the realignment of organizational structures, policies, and processes to better address worker needs

Our systematic review demonstrated that physical modifications and those involving a combination of physical modifications and cognitive processes, and physical modifications and organizational change management, were found to have positive outcomes regarding reductions in MSD symptoms and prevalence.

Many strategies aim to eliminate workers' exposures to MSD hazards and risk factors. Although it may be challenging to fully eliminate workers' exposures to all MSD risk factors, the goal should remain to reduce exposure to one or several MSD risk factors. Therefore, employers should continually examine and evaluate current interventions, explore emerging advancements, address limitations to implementation, and ensure effort is being applied to understand and address risk factors to fully tackle an employees' exposure and risk level.

Based on the findings of this review, most included interventions fell into the physical modifications category (71%). More research is needed to make strong, definitive claims about the effectiveness of other intervention types, such as cognitive processes and organizational change management interventions, before they can be applied in industries to mitigate MSD risks.

Due to this lack of high-evidence research and incidence of MSDs as outcome measurements, workplaces are called upon to partner with research institutions to advance MSD reduction and prevention initiatives to drive high-quality research forward, with an understanding of the confines of conducting studies in industry. While promising and well-established MSD interventions are currently available on the market, there is no silver bullet to mitigate this workplace concern. Different interventions may work for one employer or industry, and not another. **Current evidence found from this review suggests interventions including physical modifications and those that combine more than one domain, such as those combining health campaigns and exercise or motivational coaching and exercise, are promising for producing positive change and reducing symptoms associated with MSDs.** However, future examination is needed into these topics to see if risk is actually reduced.

Background

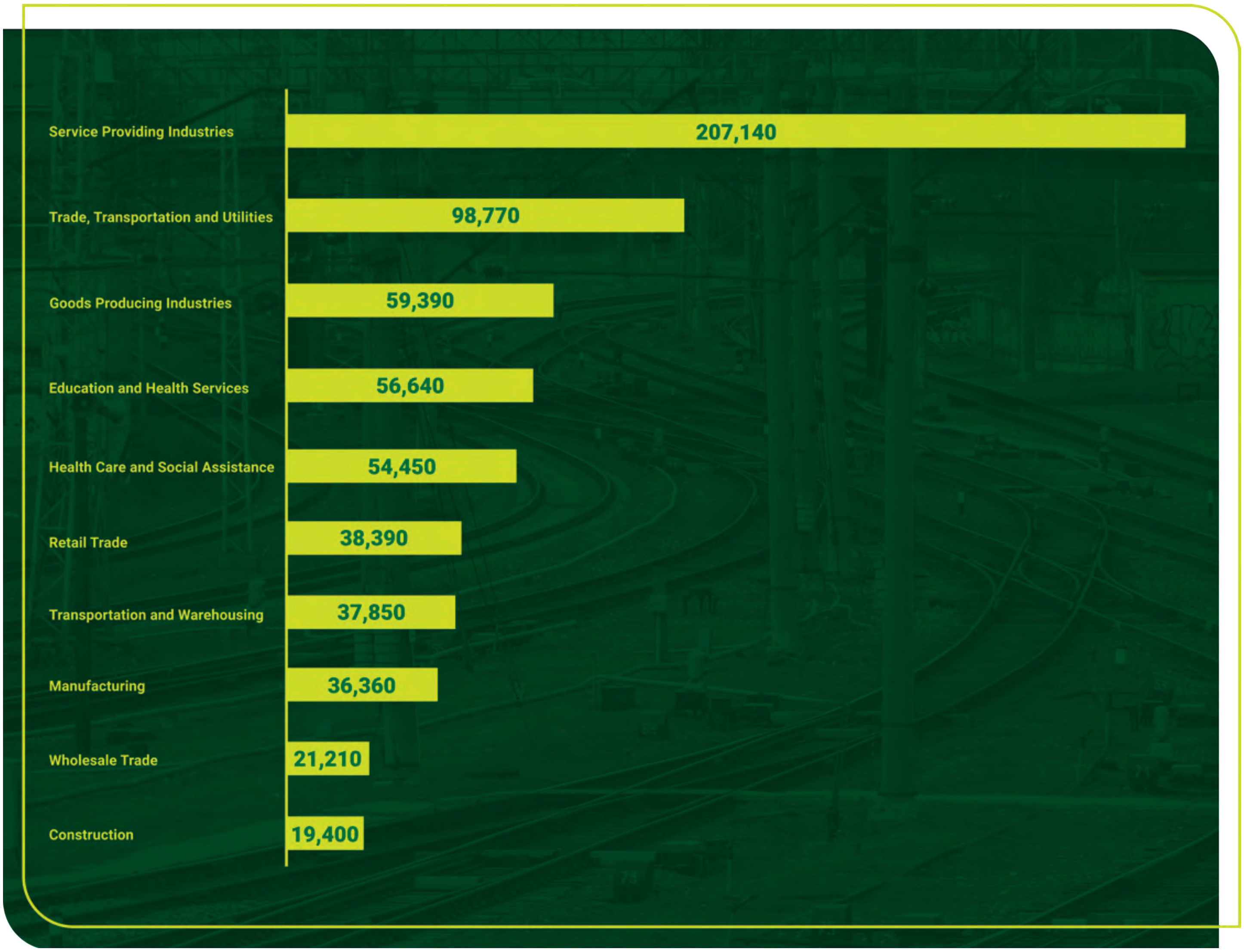
For more than 50 years, workplace modifications or interventions have been continually researched, developed and implemented to fit or modify the work and work environment to the worker's capabilities (Bach et al., 2018; NIOSH, 2015; Waters, 1994). According to *Injury Facts®* (2020), musculoskeletal disorders (MSDs) resulting in days away from work have decreased in the United States in recent years, falling 20 percentage points from 2011 to 2020 with an average annual decrease of 2.5 percentage points. However, even with decreases each year, the reported number of MSDs in 2020 was over 247,000, indicating that MSDs remain a hazard in the workplace. While improvements have been made to tackle this pervasive issue through workplace redesign, hazard and risk elimination, emerging technology, program evaluations, and laboratory-based research studies, the issue persists. MSDs remain an ongoing safety, health and well-being issue due to the complexity of risk factors related to the worker, work tasks and work environments. The fiscal impact of these injuries is further evidenced by *Injury Facts* (2020), which consistently ranks MSDs as one of the leading causes of nonfatal injury or illness events involving days away from work in the U.S. private sector.

Furthermore, the World Health Organization (2021) reports that MSDs are the most common worldwide cause of disability, involuntary retirement, and limitations to gainful employment. Our understanding of workplace injuries and MSDs, their causes, and the underlying mechanisms of different MSDs have improved over the past few decades. However, continual, high-quality research is needed to understand and develop MSD prevention solutions. The present systematic review aims to examine recent research through a rigorous methodology on interventions addressing MSDs and associated symptoms at work, and identify unresolved gaps to uncover plausible solutions.

Research Approach

To begin, our research question was: "*What workplace interventions have been demonstrated to be effective in preventing work-related musculoskeletal disorders for the top 10 afflicted industries among workers 18 years and older?*" This question was answered through a systematic literature review process (Page et al., 2021). Six electronic databases were searched for relevant peer-reviewed articles published in English between January 2011 and December 2021. The search strategy was based on the top 10 afflicted industries according to the number of MSD injuries resulting in days away from work in 2019 (*Injury Facts*, 2020). These industries, as defined by the Bureau of Labor Statistics, can be seen in Figure 1. Various iterations of the following database search terms were used: musculoskeletal, cumulative trauma, repetitive motion, stress, strain, work, occupation, industry, intervention, prevention, mitigation, reduction, ergonomics, countermeasure and risk management.

Figure 1. Number of Musculoskeletal Injuries per Top 10 Afflicted Industries in 2019



Source. Injury Facts

Note. The total number of MSD injuries in the Service Producing Industries combined with the total number of MSD injuries in the Goods Producing Industries is equal to the total number of MSD injuries for 2019. Other industries are subsets of these two, larger industries.

Inclusion and Exclusion Criteria

To identify articles regarding workplace musculoskeletal interventions, our inclusion criteria were:

Table 1. Systematic Review Inclusion Criteria

✓ Pertaining to occupational health and safety	✓ Measurement of MSD injury, pain or discomfort through self-report or physiological measures
✓ Top 10 afflicted industries	✓ Written in the English language
✓ Represent work-related MSDs	✓ Study date and data collection not before 2011
✓ Adult population (i.e., 18 years of age or older)	✓ Available as a full-length article
✓ Prevention focus	✓ Published in a peer-reviewed journal
✓ Research design included control or comparison group	

Articles that did not meet the above inclusion criteria were excluded.

Literature Search and Selection Process

The initial search produced 13,500 records. Once duplicates were removed, 8,365 articles were reviewed independently by two reviewers against the inclusion criteria. A third reviewer resolved disagreements. After excluding 8,180 articles, 185 full-text articles were assessed by the reviewers, of which 58 were deemed eligible for inclusion and evaluation. Pursuant to current research, 58 articles are within a normal range to retain in a systematic review (see Carayon et al., 2015; Gallagher & Heberger, 2013). See Figure 2 for the article inclusion flow diagram.

Early Insights

- *Most studies had small sample sizes*
- *Limited inclusion of female workers outside of healthcare*
- *Highest level of scientific rigor (i.e., control or comparison group requirement) may have excluded other less rigorous, yet informative, research on this topic*
- *Physical modifications combined with cognitive processes or organizational change management appear promising*
- *Majority of results highlighted pain and discomfort versus MSD counts or rates*

Findings and Discussion

Participant Characteristics

Demographic characteristics of the participants included were extracted to understand more about the study populations represented in the research. Studies differed widely in collecting demographic information, but useful characteristics were still identified. For example, the average size of the intervention group was 68 study participants, and the average size of the comparison group was 72 study participants. Meanwhile, the average age of participants within the intervention or control group was 39 years. On average, samples included 72% women in healthcare and 38% women in non-healthcare industries. MSD intervention research data collection occurred in 25 different countries, with most articles containing data collected in the U.S., Iran, Denmark and Germany. Additional information regarding data abstracted and detailed results from included articles are available upon request.

MSD Intervention Categories

Articles were grouped into the three main categories of physical modifications, cognitive processes, and organizational change management. As aforementioned, physical modifications is comprised of two sub-categories: physical environment and equipment, and physical activity. The studies included in the systematic review were organized by intervention type rather than by industry to encourage non-industry-specific MSD intervention development.

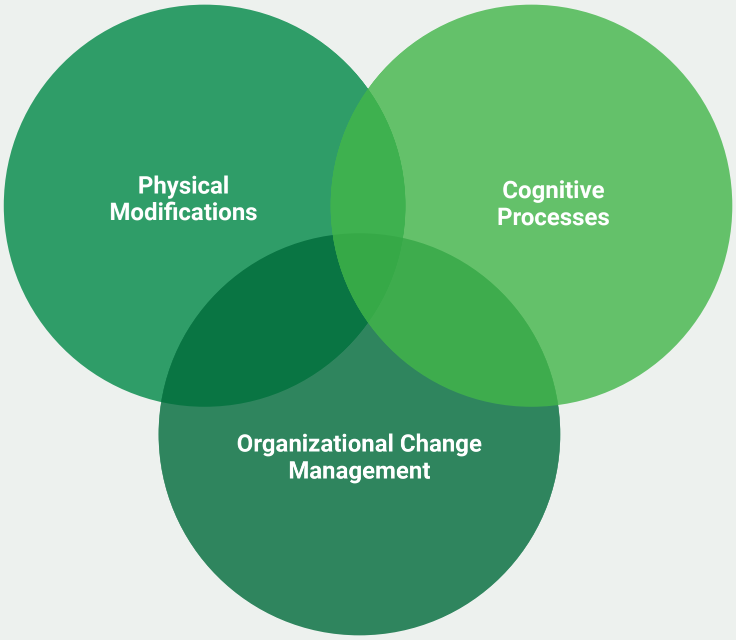
Figure 2. Article Inclusion Flow Diagram

Figure 3. Intervention Types and Definitions

Physical Modifications are comprised of two sub-categories that are concerned with 1) the physical environment and equipment as it relates to human interaction within the workplace; and 2) physical activity as it relates to human performance. Articles within this review employing physical modification interventions generally focused on posture, manual material handling, physical devices and equipment, and exercise.

Cognitive Processes is concerned with mental processes and decision making among humans in the workplace. Articles within this review describing cognitive processes interventions included behavior change through motivational coaching or counseling and problem solving.

Organizational Change Management is concerned with the realignment of organizational structures, policies and processes to better address worker needs. Articles within this review describing organizational change management interventions focused on communication, workstation design, rest breaks, participatory workshops and trainings.



Some interventions also spanned across several of the intervention categories. **This approach reflects the notion that MSDs are multifactorial in nature and can develop from a wide variety of risk factors.** Therefore, employers may need multiple solutions to address work-related MSDs. Articles were further organized into seven categories (see Table 2).

Table 2. Number of Articles per Intervention Category

Intervention	*Count*
Physical Modifications	**41**
Equipment and devices	11
Exoskeletons	6
Exercise	16
Other/multi-faceted	8
Physical Modifications + Cognitive Processes	**5**
Exercise + Cognitive Processes	4
Other/multifaceted + Cognitive Processes	1
Organizational Change Management	**4**
Physical Modifications + Organizational Change Management	**4**
Exercise + Organizational Change Management	2
Other/multifaceted + Organizational Change Management	2
Physical Modifications, Cognitive Processes + Organizational Change Management	**2**
Cognitive Processes	**1**
Cognitive Processes + Organizational Change Management	**1**

Note. Equipment and devices, exoskeletons, exercise, and other/multi-faceted contribute to the 41 Physical Modifications articles utilized in the review, while Physical Modifications + Cognitive Processes and Physical Modifications + Organizational Change Management also have subcategories contributing to their totals. Articles employing Physical Modifications, Cognitive Processes + Organizational Change Management used a wide array of strategies, and are therefore not further broken into subcategories.

The high representation of articles focusing on physical modifications parallels previous research.

Practical Workplace Implications

As seen in Tables 3 and 4, physical modification interventions are commonly employed within workplaces. Evidence of their effectiveness appears to be mostly positive, with **36 of 41 articles using physical modifications demonstrating positive impacts on musculoskeletal discomfort or pain.** In this review, patient-transfer assistive devices, active seat suspensions, exoskeletons, custom shoe insoles, educational training, walking, resistance training, and stretching were also shown to reduce MSD-related symptoms. However, it is worth noting while these devices and exercises may help reduce the symptoms of MSDs, they do not address the risk or the actual root cause of the hazard.

Table 3. Summative Effectiveness Results by Intervention Category

Intervention	*Effectiveness Results*
Physical Modification	Positive
Cognitive Processes	Positive*
Organizational Change Management	Mixed*
Physical Modification + Cognitive Processes	Positive*
Physical Modification + Organizational Change Management	Positive*
Cognitive Processes + Organizational Change Management	Insignificant*
Physical Modification, Cognitive Processes, + Organizational Change Management	Mixed*

*Note. * = a small number of included studies (n < 10); interpret with caution*

Table 4. Number of Interventions and Effectiveness by Industry

Industry	P.Ex.	P.ED.	P.Exo.	P.O/M	C	O	P,C	P,O	C,O	P,C,O	Total
Healthcare	✓✓✓	✓✓✓✓	✓	✓✓✕		✓✕✕	✓✓✕	✓	✓*	✓✕	21
Manufacturing	✓✓✓✓✓	✓	✓✓✓✕	✓✓			✓	✓			14
Office work	✓✓✓✓✓✓	✓✕✕		✓	✓		✓	✓			13
Construction	✕	✓	✓	✕		✕		✓			6
Transportation		✓✓									2
Education				✓							1
Goods producing	✓										1
Total	16	11	6	8	1	4	5	4	1	2	58

*Note. P = Physical Modification, C = Cognitive Processes, O = Organizational Change Management; Ex = Exercise, ED = Equipment & Devices, Exo = Exoskeleton, O/M = Other/Multifaceted, ✓ indicates a unique study in which the intervention was tested and was effective, X indicates a unique study in which the intervention was tested and was ineffective, * = Intervention yielded reductions in risk but not reductions in experienced MSD pain/symptoms*

Given the findings of this review, physical modification interventions appear to be more effective at reducing workplace MSD symptoms when they are combined with cognitive processes, such as motivational coaching. As with combining physical modification and cognitive processes, combining physical modification and organizational change management interventions appears promising as well. Health campaigns, when combined with a physical modification, resulted in reduced MSDs and associated symptoms.

Workplaces are strongly encouraged to include the elements of behavior change, motivational coaching, or a properly implemented health campaign to new or existing interventions within the physical modification domain.

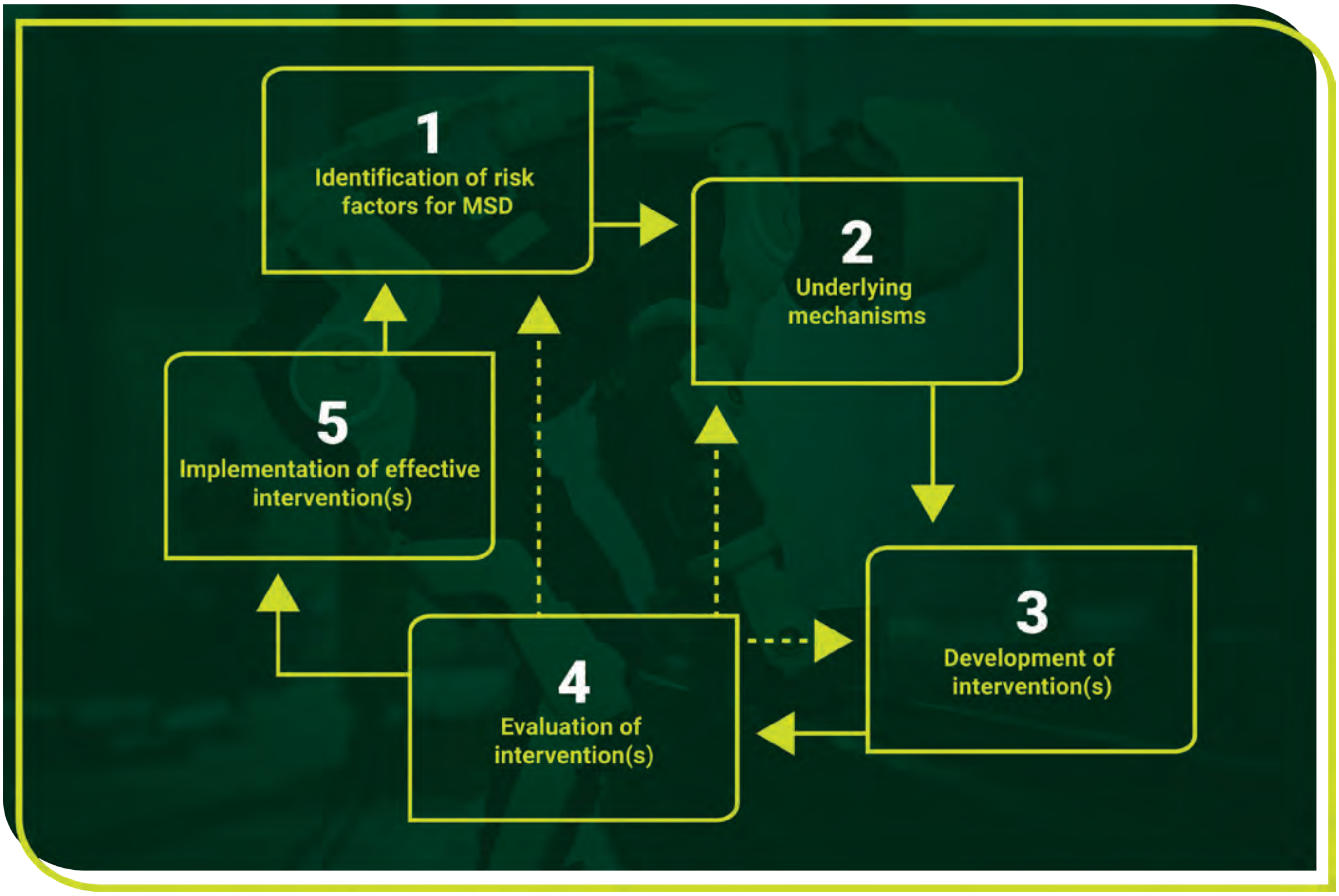
Taken together, **it is highly recommended that workplaces include a cognitive process or organizational change management intervention in combination with a physical modification intervention as they develop or refine their MSD reduction initiatives.** This approach will better ensure those interventions reduce and prevent work-related MSDs and associated symptoms. Once developed and piloted, organizations can more accurately evaluate an interventions' effectiveness and calculate the return on investment. As with all interventions, it is also imperative for employers to listen to employee feedback when implementing or revising interventions.

Organizational change management interventions alone do not appear as promising as combination interventions. However, given the low number of studies solely implementing organizational change management, this finding should be viewed with caution as more research is needed. While combining two domains appears beneficial, combining all three domains types produced mixed results. Given only two articles were identified within this combined category, it stands to reason more research is needed to investigate whether combining all three intervention domains effectively reduces work-related MSDs and associated symptoms. Since the prevalence of work-related MSDs is a global issue, workplaces are encouraged to share their promising protocols and methods for MSD reduction and thus motivate others to do the same. Even though interventions and technologies have advanced, there remain limited highly rigorous research findings showing an unequivocal reduction in true MSD cases and injuries, as evidenced by this review. Given most MSD-related data reflects pain and discomfort, a need for data tracking and reporting on actual counts of MSDs exists. The current lack of MSD data may stem from reporting inconsistencies, historical focus on injuries as a whole, government entities requiring reporting only for certain injuries, or organizations choosing not to share their MSD-related injuries or rates. In order to improve reporting inconsistencies and fully understand the breadth of the MSD issue within the workplace, organizations need to be transparent regarding their MSD injuries and rates. This would lead us one step closer to solving for this prevalent workplace issue. Furthermore, workplaces should also be encouraged to take proactive steps to eliminate risk factors for MSDs and share findings.

Workplaces are called upon to collect, record and track MSD cases and injuries, as well as report associated rates to aid in conquering the global MSD crisis.

Figure 4 is modified from a highly acclaimed article by van der Beek and team (2017), who suggested a framework for MSD prevention research. Although the authors suggested the first step in this framework is to assess the incidence and severity of an MSD, we feel identifying risk factors as the starting point can lead to a better understanding of targeting for effective interventions. Therefore, this framework begins with awareness of MSD risk (via incidence of the MSD or identification of risk factors) in step 1 and ends with step 5, implementing effective interventions. One can revisit steps 1 to 3 for further refinement if an intervention is found ineffective (step 4). The findings of this current systematic review agree with the above recommendations, especially focusing on understanding the underlying mechanisms of MSDs to inform the development and implementation of effective interventions. Visit nsc.org/msd for additional resources on how to design and develop a MSD program.

Figure 4. Extra Insight - Designing an Intervention



Directions for Future Research

Overall, the current systematic review demonstrated a reduction in musculoskeletal symptoms is possible through various interventions encompassing three domains (see Tables 3 and 4). Previous research has extensively explored work-related risk factors and physical limits of the body; however, more research is needed and should be directed in the development of impactful interventions.

Physical Modification Interventions

Ergonomics means fitting the job to the worker's abilities and not adapting workers to job demands. Therefore, the first step in mitigating risks for MSDs focuses on eliminating physical risk factors of the job or reducing exposure to them (NIOSH, 2015). Thus, a majority of intervention studies investigated in the current review fall within the physical domain of ergonomics, as many studies aim to create interventions eliminating physical risk factors (Mulimani et al., 2018; van der Beek et al. 2017).

Equipment and Devices

In addition, studies included in this systematic review highlight the importance of using innovative product designs (e.g., an active suspension seat design as compared to traditional seating) as well as the right patient handling equipment to reduce exposure, implying the importance of addressing the causal factors of pain and potential MSD risk through elimination of hazards and/or workplace redesign (NIOSH, 2015). More high-quality research on equipment and devices is still needed to replicate such findings in diverse worker populations and in a variety of workplace settings that better reflect the current workforce.

Exoskeletons

Numerous studies on wearables, as well as exoskeletons, potentially show a reduction of risk for MSDs. However, the lack of large sample sizes and comparison groups is a weakness of these studies to date, and thus led to the exclusion of many such studies from this review. While an exoskeleton may positively impact the body part most used during task performance, it may be uncomfortable to wear or cause one body part to compensate for another (Howard et al., 2020). To this effect, sizing and fit evaluations of exoskeletons and user feedback are crucial to their wide acceptance (Stirling et al., 2020). For example, it has been found that workers may need to adjust how they complete work tasks while wearing an exoskeleton, resulting in increased cognitive demands potentially offsetting the advantages of using exoskeletons during work (Zhu et al., 2021).

Therefore, further research and future product design should investigate and incorporate the physiological and biomechanical implications of these wearable devices on the human body, develop workplace standards for their usage and understand barriers to employee adoption (AIHA, 2020; Howard et al., 2020). To address some of these issues, ASTM International launched a committee on exoskeletons and exosuits in 2017. The committee will develop standards for these new technologies, addressing safety, quality, performance, ergonomics and other relevant usability aspects for the wearer (ASTM International, n.d.).

Physical Activity

Exercise-based interventions reduced MSD-associated symptoms for workers in a variety of industries. However, more research is needed to understand the nuances of intervention duration, intensity and participant exercise adherence, including why and when exercises are likely to lessen symptoms. For instance, walking as an intervention for MSD exposure and injury prevention needs further research due to the limited number of included articles within this review. Additionally, from the included studies, we can ascertain that stretching, when combined with additional control measures, may be a viable option to provide workers with relief from musculoskeletal pain. Yet more research is needed to ensure effectiveness across industries. To this effect, a systematic review by da Cost and Vieira (2008) emphasized that stretching in isolation should not be encouraged for MSD prevention. Instead, one should first address the primary causes of pain and potential risk for MSDs by eliminating the hazard or redesigning the work. **Therefore, while stretching may be a viable option to lessen MSD pain and discomfort, more research is needed. Emphasis on intervention design should stay centered on risk elimination or work redesign.** Lastly, studies reported the positive impact of implementing yoga or Pilates. This area needs more robust research before such interventions can be horizontally deployed to lessen MSD discomfort in other organizations.

Cognitive Processes and Organizational Change Management Interventions

Workplace safety and health researchers should aim to design studies utilizing cognitive processes and organizational change management approaches within their interventions. While cognitive processes and organizational change management interventions appear promising, more in-depth studies with control groups are needed to improve understanding of their effectiveness. While multi-faceted interventions combining physical modifications with cognitive processes or organizational change management factors appear to generate positive results in preventing MSDs, more evidence is needed to ascertain whether this is a true effect. For example, prevention methods focusing on risk factors alone aren't always successful partly due to a lack of understanding of the causes of MSDs in the workplace and/or a lack of well-designed interventions (van der Beek et al., 2017). Therefore, physical modifications in tandem with organizational change management or cognitive processes interventions appear promising and deserve further attention.

> *Future research on MSD prevention should also focus on understanding the vital role that leadership support can play in implementing successful interventions.*

Study Design

Additionally, many of the top afflicted industries (refer to Table 4) were not adequately represented within the found research. This may be due to factors such as the lack of emphasis on systematic analysis in these industries, lessened interest in allowing for research within certain industries, union or employment agreements, or a desire for proof of concept prior to piloting. **Therefore, researchers should aim to apply rigorous study designs to other commonly afflicted industries where risks are constantly changing (i.e., retail, transportation, warehousing) to provide more representative findings and potential solutions.** Many of the included studies also highlight the importance of conducting future research to better understand the role of psychosocial and organizational factors, including job control and autonomy, stress, colleague support and off-the-job factors.

While more work on intervention research is clearly needed, it is also imperative to address first the causal factors of pain and potential MSD risk through hazard elimination and/or workplace redesign.

Furthermore, the authors of this systematic review call for more emphasis on studies that include long-term follow-up, an intervention group, and a non-intervention (control) group to better determine MSD intervention effectiveness and cause-effect relationships with minimal bias or confounding factors (e.g., age, gender, sex, education). While not always feasible in practice due to study design complexities and potentially leaving employees in the control group temporarily exposed to risk, the level of scientific evidence attained from the rigor is unmatched. Such studies, if results are found beneficial, can be implemented in other worker groups with effectiveness assurance. More so, the collection of specific metrics, such as MSD injury rates, pain, and discomfort, as well as risk reduction, can be continued after the study and aid an organization in understanding their MSD-related metrics, opportunities for celebration and opportunities for improvement. Employers should feel empowered to share their MSD journey, improvements, and lessons learned by collaborating with others on a similar path and through metric sharing. Taken together, well-designed, high-quality, effective and sustainable interventions are needed within industry to support each other and prevent work-related MSDs.

The studies included in this systematic review did not have or adequately report on ethnic or racial representations of study participants. This may be due to the protection of sensitive information, lack of reporting requirements by publication journals, or failure of further inquiry by researchers. **Further research is needed to expand upon MSD prevention measures among diverse populations, especially for work completed by marginalized communities.** Moreover, many of the included studies lack female study participant representation, apart from those in the healthcare industry. This may be due to underrepresentation within certain industries. However, further research, including diverse samples adequately representing females in the workplace, is needed. Several authors of included articles also highlighted the need to include workers of more varied age groups, particularly older ages, in future research. This is vital considering the current shift to an aging workforce.

Adherence to intervention protocol was subpar within our included studies and future studies should focus on methods for participant retention. There was a notable lack of consistency across studies regarding intervention quality and implementation, meaning wide variation existed in the frequency, duration and intensity of interventions studied. Due to a lack of best practice standards for MSD interventions within the workplace, future studies should pay more attention to type, quality and implementation strategies of their intervention while keeping in mind participant burden and organizational constraints. It is well understood that strong experimental study designs include participant follow-up at varying times post-intervention or -treatment (Hill et al., 2016; Llewellyn-Bennett et al., 2016). Many included studies discuss that a longer intervention or follow-up duration could have strengthened findings, which would aid in determining whether the intervention truly reduced MSDs and injuries, in addition to pain or discomfort. This is pertinent as only four (7%) of the included 58 articles in this review reported on measurable, true MSD outcomes, while others reported on MSD symptoms such as pain or discomfort. While most studies in the present review include follow-ups with participants at either 6- or 12-months post-intervention, studies should aim for follow-ups after at least a year to better understand the long-term effects of the interventions. Therefore, **future work in this area should aim to include post-intervention follow-up periodically out to and beyond 12 months to accurately measure sustained intervention impact. This length of follow-up also allows for a study design that is enabled to examine an interventions' return on investment.**

Limitations

Concerning possible limitations of the current review, only peer-reviewed publications were included given our interest in evidence-based MSD prevention and intervention measurement outcomes. Gray literature may include relevant articles from trade journals, business reports, conference proceedings, and other white papers. Additionally, as with all literature reviews, this systematic review is subject to publication bias, in which articles with significant findings are more likely to be submitted for publication and published. Our inclusion criteria were limited to English-language peer review journals based on abilities of the authors, and, for ethical reasons, adult worker study participant populations. Additionally, omitting studies with data collected before 2011, while intended to only provide more recently developed effective interventions, may have excluded successful MSD prevention interventions developed earlier. Several studies included were randomized control trials, the gold standard for efficacy research, but there is still a need for further research on this topic that utilizes this level of study design. As articles were only eligible to be included in this review after comparison to a pre-determined list of criteria, a wider inclusion criterion (e.g., industries beyond the top 10 most afflicted, studies without control or comparison groups) may have captured additional articles. Moreover, as with all systematic literature reviews, there is the possibility that articles meeting our inclusion criteria were not captured due to certain constraints, such as access to relevant databases or articles. Lastly, this review focused on prevention intervention techniques targeting the reduction of MSDs, musculoskeletal pain or discomfort. Studies with interventions that aim to reduce risks for MSDs would also be beneficial to expand upon.

Conclusion

In summary, eliminating the hazard or reducing exposure to risk factors should be the primary goal of an MSD intervention. Although it may be challenging to fully eliminate workers' exposures to all MSD risk factors, the goal should remain to reduce the worker's exposure to one or several MSD risk factors. Challenges in reducing risk can be for a variety of reasons, including the type of job or task being performed, lack of support from management or financial constraints. When this occurs, several administrative controls are available as options, but are best recommended when combined with other hierarchy of control measures. To this effect, this systematic review highlighted physical modifications (e.g., exoskeletons, resistance training), cognitive factors (e.g., motivational coaching) and organizational factors (e.g., change management) that may be implemented within industry. As with all interventions, due diligence must be exercised prior to implementation to ensure proper fit and execution.

The present white paper is part of the MSD Solutions Lab's overarching effort to examine the state of innovation in addressing MSD issues in the workplace. Therefore, this paper is the first of several research insights exploring knowledge gaps in research aimed at finding promising solutions for MSD risk reduction. While promising and well-established MSD interventions are currently available on the market, there is no silver bullet to mitigate this workplace concern. Different interventions may work for one employer or industry, and not another. Current evidence found from this review suggests interventions including physical modifications and those that combine more than one domain, such as those combining health campaigns and exercise or motivational coaching and exercise, are promising for producing positive change and reducing symptoms associated with MSDs. More research is needed to make definitive claims about the effectiveness of other intervention types, such as organizational change management and cognitive processes interventions or those utilizing special equipment, and the effectiveness of combining three domains within an intervention. Furthermore, it was found that interventions in the physical modifications domain are greatly represented in the literature, while interventions in cognitive processes and organizational change management domains have not been as extensively studied. Additionally, while many articles reported a significant impact of interventions on MSD pain or discomfort, no intervention is perfect. Interventions often improved some aspects of MSD symptoms but not all, as limitations were present. Employers are primed to partner with researchers to examine the effectiveness of their current MSD interventions or implementation of an intervention and generate high evidence studies, and set the example for MSD tracking and information dissemination.

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